Energy, Mines and Resources Canada | Énergie, Mines et Ressources Canada

CANMET

Canada Centre for Mineral and Energy Technology | Centre canadien de la technologie des minéraux et de l'énergie

CSA STANDARD M424 - ITERATION No. 4
FLAMEPROOF DIESEL-POWERED VEHICLES FOR USE IN UNDERGROUND MINES

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Canadian Explosive Atmospheres Laboratory
March, 1983

Prepared as a working document for further development by the "CSA Technical Committee on Underground Diesel Equipment".

This document is an unedited interim report prepared primarily for discussion and internal reporting purposes. It does not represent a final expression of the opinion of the Canada Centre for Mineral and Energy Technology (CANMET)

Ce document est un rapport provisoire non-révisé et rédigé principalement aux fins de discussion et de documentation interne. Il ne représente nullement l'expression définitive de l'opinion du Centre canadien de la technologie des minéraux et de l'énergie (CANMET)

39pp

MICROMEDIA

AUG 19 1983

ENERGY RESEARCH PROGRAM
MINING RESEARCH LABORATORIES
DIVISION REPORT ERP/MRL 83-30 (TR)

PREFACE

Mssrs. Len Kitchener and Richard Crawshay (Committee Members representing INCO and CANMINE respectively) were engaged under contract to EMR/CANMET to expedite the work of the CSA Diesel Technical Committee by preparation of a Standard Document incorporating the submitted suggestions of members arising from consideration of Iteration 2 of the Standard.

This process was completed on March 24/83 and resulted in Iteration #3, which removed considerable administrative, design, and background material and produced a document more clearly based on equipment performance requirements.

Detailed consideration by CANMET flameproofing specialists (including J. Bossert, G. Lobay, P. Mogan and D. Dainty) and two days of consultation among CANMET personnel and Mssrs. Kitchener and Crawshay, resulted in further changes which yielded the document presented here - Iteration #4, produced in the CSA standard format.

Distribution of Iteration #4 to the membership will permit careful individual study of the document. The membership will be requested to classify their suggestions for change into three categories:

1. changes of substantial technical importance and absolutely required from the member's point of view (including a rationale statement)

2. desirable technical changes but not absolutely required,

3. editorial changes, and listing of terms which require definition plus suggested wording of definitions.

A subsequent Committee meeting in August or September of 1983 will afford an opportunity to give consideration to and agreement upon inclusion of the above changes in order of priority 1,2, and 3 and will result in a document suitable for forwarding to the CSA Steering Committee for their modification and/or approval perhaps during the balance of 1983.

Parallel to the final Standard it will be necessary to prepare a design guide (possibly including suggestions for a code of practice) and an administrative document, all of which will be prepared by CANMET which agency will be required to shoulder the bulk of the certification work.

PREFACE

MM. Len Kitchener et Richard Crawshay (Membres du comité représentant INCO et CANMINE respectivement) ont été tenu par contrat envers EMR/CANMET pour terminer les travaux du Comité technique de la CSA sur le diesel en préparant un document de normalisation comprenant les suggestions soumises par les membres après avoir considéré la réitération 2 de la norme.

Ces travaux ont été terminés le 24 mars 1983 et sont à la base de la réitération 3, qui exclue plusieurs détails d'administration et de conception et des renseignements recueillis antérieurement. Le résultat est un document plus clair fondé sur les exigences de fonctionnement de l'équipement.

Les spécialistes des techniques de résistance aux flammes du CANMET (J. Bossert, G. Lobay, P. Mogan et D. Dainty) ont étudié la question avec soin. De plus, on a consulté pendant deux jours d'autrés membres du personnel du CANMET et MM. Kitchener et Crawshay. Tout ceci a contribué à ce qu'on apporte des changements et à ce qu'on publie le document présenté ici - Réitération 4, produit selon le format des normes de la CSA.

Les membres pourront étudier le document avec soin puisqu'on le distribuera à chacun. Les membres devront alors classer leurs suggestions pour apporter des changements selon les trois catégories suivantes:

1. changements importants et absolument nécessaires dans le domaine technique selon le membre (accompagnés d'un exposé rationnel),

2. changements techniques désirables mais pas absolument nécessaires,

3. changements éditoriaux et à apporter sur la liste des termes qui demandent une définition et suggestion de définition.

En août ou septembre 1983, il y aura une rencontre du Comité qui permettra d'examiner les changements proposés et éventuellement de les accepter en ordre de priorité (1, 2 et 3) et finalement de produire un document qui pourra être présenté au Comité de direction de la CSA qui le modifiera et/ou l'approuvera peut-être au cours de 1983.

Pour accompagner cette norme, il sera aussi nécessaire de préparer un guide de conception (incluant possiblement des suggestions sur un coce de pratique) et un document administratif, qui seront tous préparés par le CANMET et qui devra partager les travaux de certification.

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Underground Diesel Equipment

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1. Scope

1.1 This Standard describes the technical requirements and procedures necessary for the design, performance and testing of new flameproof, diesel-powered, non-rail-bound, self-propelled machines for underground use in Canada, in hazardous locations characterized by the presence of methane and of combustible dust having a spontaneous ignition temperature not less than 150°C (300°F).

1.2 Other categories of hazard, such as for example, the presence of combustible gases (methane, propane etc.) with no combustible dust, may suggest more or less demanding requirements which, however, are not defined in this standard.

1.3 The clauses defining engine emissions and flameproof requirements do however, pertain to all diesel engines used underground where the category of hazard defined in 1.1 is applicable, regardless of the type of machine considered.

1.4 Rail-bound vehicles are excluded from this standard.

2. Definitions

3. Vehicle Performance Requirements

3.1 General Section 3 covers performance requirements, for the range of machines described in the scope of this document (Section 1), which shall be met in order to qualify for certification.

3.2 Industrial Safety Requirements

3.2.1 Lighting

3.2.1.1 The electrical system associated with vehicle lighting must meet the requirements specified in the Electrical Equipment section 3.3.2.

3.2.1.2 All vehicles shall be equipped with two or more clear lighting units, each separately fused, permanently attached and directed to illuminate the roadway in the direction of travel. Each lighting unit shall produce illumination equivalent to but not less than that provided by a 60 watt incandescent sealed lighting unit as described in SAE Standard J598b.

3.2.1.3 Vehicles capable of operating in two directions must be equipped as per 3.2.1.2 at both ends of the vehicle so that the same illumination performance can be achieved in either or both direction of travel, at the operator's discretion.

3.2.1.4 Red, reflective, non-incendive material shall be attached to both ends of each vehicle, clear of working surfaces, so that the driver of another vehicle which is equipped as per 3.2.1.2 can detect reflection from a portion of the material at a range of 60 metres, in clear air, when using only the headlamps described in 3.2.1.2 as a source of illumination. The minimum area of red, reflective non-incendive material attached to each end of a vehicle shall be 460 cm^2 (70 in^2).

3.2.1.5 Additional lighting, required for illumination of a workplace while the vehicle is stationary, may be attached to the vehicle and shall conform to provision 3.2.1.1.

3.2.2 Hydraulic and Pneumatic Systems

3.2.2.1 Hydraulic systems are defined as consisting of hydraulic fluid, a hydraulic power source, a reservoir, controls, actuators or motors, together with interconnecting conduits and accessories which are used to mechanize functions of a machine.

3.2.2.2 All hydraulic systems with the exception of those listed in clause 3.2.2.3 shall conform to the following clauses:

3.2.8 Safety Shutdown provision
3.4.1 Surface temperature limitation
3.4.2 Use of fire-resistant fluids

3.2.2.3 Hydraulic systems and components excluded from the requirements of clause 3.4.2 are as follows:

(a) Engine-related hydraulic systems such as hydraulic valve lifters, hydraulic cooling fan drives, lubricating systems and fuel and injection systems.
(b) Torque Converters
(c) Transmissions
(d) Retarders
(e) Axles
(f) Braking systems employing multiple friction discs encased in an oil bath.
(g) Braking systems which are not power operated or not power assisted.

3.2.2.4 The hydraulic filler cap shall be clearly and distinctively marked to differentiate it from any other filler cap so as to minimize the possibility of inadvertent introduction of incorrect fluid.

3.2.2.5 Pneumatic systems, including air compressors, shall conform to the following clauses:

(a) 3.2.8.5 Safety shut down provision
(b) 3.3.9 Air compressors
(c) 3.4.1 Surface temperature limitation

3.2.2.6 Air reservoirs shall comply with the requirements of CSA Standard B51-M 1981.

3.2.2.7 Air reservoirs shall be constructed and located or protected so as to be capable of safely resisting damage in a vehicle collision.

3.2.3 Fuel System

3.2.3.1 Fuel tanks shall maintain the fuel at a temperature differential of less than 5C° (9F°) below the flash point of the fuel specified in clause 3.2.5.6.

3.2.3.2 The capacity of any fuel tank shall not exceed that required for eight hours of full load engine operation.

3.2.3.3 Each fuel tank shall be tested by the manufacturer to be water-tight at 30 KPa gauge (4.35 psig) and this shall be certified or stamped on the tank by the manufacturer.

3.2.3.4 Fuel tank vent openings shall be provided to maintain atmospheric pressure within the tank and shall be designed to prevent leakage of fuel especially when the tank is inverted. Filler caps, whether incorporating vent openings or not, must also meet this requirement. These must be located remotely from hot surfaces and permanently attached to the vehicle to prevent loss.

3.2.3.5 Fuel lines shall be constructed of fire resistant material and shall be routed so as to avoid hot engine surfaces and moving parts and to afford a maximum of mechanical protection.

3.2.3.6 Whenever practicable, fuel systems shall be so designed that in the event of a failure of any fuel line on the suction side of the fuel pump, fuel will not flow from the tank either by gravity or syphon.

3.2.3.7 Fuel transfer and injection pumps are referred to in clauses 3.2.5.3, 3.2.5.4 and 3.2.5.5.

3.2.4 Driver's Control Station, Controls and Instruments - Vehicle Mounted for Vehicle Control (other functions such as drilling, materials handling, etc. are excluded)

3.2.4.1 For requirements for ROPS, FOPS or other related structures, refer to clauses 3.2.4.20 through 3.2.4.24.

3.2.4.2 Vehicles intended to carry a driver shall be equipped with a driver's seat and a seat belt to SAE Standard 386.

3.2.4.3 Vehicles intended to carry passengers shall be equipped with a seat and seat belt to SAE Standard 386 for each passenger.

3.2.4.4 The minimum dimensions for each seat and of the space provided for the occupant shall be in accordance with the appropriate SAE Standard.

3.2.4.5 Human factors associated with control grouping and operating forces shall be in accordance with the appropriate SAE Standard.

3.2.4.6 Instruments and an audible or visible alarm shall be provided to indicate to the driver unsafe conditions relating to the following:

a) hydraulic drive or coupling pressure
b) pneumatic system pressure
c) brake system pressure(s)
d) engine coolant temperature
e) engine oil pressure
f) transmission/torque convertor oil temperature
g) retarder system temperature
h) loss of water in exhaust system
i) air compressor discharge temperature

Additional instruments may be provided at the manufacturer's discretion. All instruments required by this clause shall be displayed in accordance with the appropriate SAE Standard.

3.2.4.7 The vehicle driver's cap lamp shall be acceptable for illumination of control station indicators.

3.2.4.8 Driver Control Station, Controls and Instruments - Remote Mounted etc. (to be developed)

3.2.4.9 to 3.2.4.19 (Reserved Paragraphs)

3.2.4.20 Protective Structures

Vehicles covered by this code are intended to be operated only in mines whose openings have been regularly inspected and made safe and to be operated on roadways or in openings considered adequate for safe operation. However in cases of mines which, because of particular conditions, offer hazards of unstable ground, steep roadways, unusual loading or

dumping arrangements, etc., the mine operator or the provincial authority may require that special protection be attached to and become part of a vehicle covered by this code. This protection may fall into one of the following categories:

Rollover protective structure - ROPS
Tipover protective structure - TOPS
Falling object protective structure - FOPS

3.2.4.21 The performance criteria for Rollover Protective Structure (RQPS) when specified shall be to CSA Standard 8352-M 1980. Each ROPS shall be permanently marked showing:

The Manufacturer's name and address
The Model Number
The Make and Model Number of the machine which it is designed to fit.

3.2.4.22 The performance criteria for Tipover Protective Structures (TOPS) when specified, shall be in accordance with the appropriate CSA Standard when developed.

3.2.4.23 The performance criteria for Falling Object Protective Structures (FOPS) when specified, shall be to CSA Standard...(to be developed).

3.2.4.24 The vehicle attachment points, interfacing with the ROPS, TOPS or FOPS required for retrofitting a structure, shall be to the manufacturer's specification and shall in turn conform to the appropriate code referred to in clauses 3.2.4.21, 3.2.4.22, or 3.2.4.23.

3.2.5 Engine and Drive

3.2.5.1 Liquid cooled engines shall be used.

Note: Current (1983) air cooled engines are considered unsuitable for use in gaseous mines because of the high surface temperatures which they generate.

3.2.5.2 The engine construction shall conform to the flameproof requirements outlined in Clause 3.3.5.

3.2.5.3 If the engine fuel system incorporates adjustable components which control the fuel flow rate to the combustion chambers and/or the maximum engine RPM, then such adjustments shall be set to the required values so that the

engine will perform within the emission limits specified in Clause 3.5.1. The adjustment shall only be made by a person authorized to do so and on completion shall be sealed with a wire and lead seal. The governor/injection system shall function so that the air flow is not directly affected.

3.2.5.4 The maximum fuel rate shall be limited by the emission requirements described in clause 3.5.1.

3.2.5.5 The approved maximum sea level allowable fuel injection rate and the approved high idle engine RPM shall be stamped on a plate permanently attached to the pump or governor housing. Changes to the data stamped on the plate shall only be made on the approval of the Certifying Agency. A second plate shall be permanently attached to the pump or governor housing on which a lesser or greater allowable fuel injection rate shall be stamped, when appropriate, so as to conform to an altitude correction or special ventilation requirement stipulated by a Provincial Authority.

3.2.5.6 The fuel employed in certification tests shall conform to the appropriate CGSB (Canadian General Specification Board) Specification.

3.2.5.7 The maximum rated output shall be that which the engine delivers at the maximum allowable fuel injection rate and rated speed when operating with the engine air intake system and the engine exhaust system specified in clauses 3.3.4 and 3.3.6 below.

3.2.5.8 The engine shall be tested on a dynamometer as described in clause 4.9 and shall conform to the requirements described therein.

3.2.6 Steering - Wheeled Vehicles All vehicles exceeding 2500 Kg (5512 lbs) gross vehicle weight and capable of travelling at speeds in excess of 20.0 kph (12.4 mph) shall meet the performance criteria of SAE Standard J53.

3.2.7 Braking Systems

3.2.7.1 The braking systems described herein apply to vehicles having a maximum speed of up to 32.2 km/h (20 mph)

and a maximum gross vehicle mass of less than 90 metric tons (99.2 tons).

3.2.7.2 All vehicles shall be fitted with a durable and permanently affixed plate on which are indelibly recorded the year of manufacture, the name of the manufacturer, the serial number, the model number, the gross vehicle weight, the maximum grade on which the vehicle may be operated and perform according to the Braking System requirements of this standard.

3.2.7.3 Braking Systems shall meet the stipulations of the 3.3.7 Explosion-Proof (Flameproof) Requirements.

3.2.7.4 Braking Systems shall meet the requirements of the 3.2.9 Safety Shutdown System.

3.2.7.5 Braking Systems which are not failsafe but depend on the application of hydraulic or pneumatic power shall incorporate a reservoir capable of sustaining at least 5 consecutive applications of the brakes with the power source inoperative.

3.2.7.6 The inherent braking effect of a hydrostatic drive system is accepted as the service brake system provided that the crawling speed, with the drive control in the neutral position when descending the maximum grade as described in clause 3.2.7.2 shall not exceed 10 m/minute (0.37 mph), and the parking brake shall be automatically applied when the hydrostatic drive control is in the neutral position.

3.2.7.7 Braking Systems shall meet the performance requirements as stated in the following clauses.

3.2.7.8. Braking terms used are defined as follows:

(a) A braking system is defined as the system which begins at the machine component (pedal, lever, etc.) that must be actuated by the operator or automatic means to initiate a brake application, and ends with the tire.

(b) Service Braking System: the primary system used for stopping and temporarily holding the machine.

(c) Secondary Stopping System: the system used for stopping a machine in the event of any single failure in the service braking system or when the operator deems it necessary.

(d) Parking System: the system used to hold a stopped machine stationary.

(e) Common Components: the braking systems may use common components. A common component is defined as a component that performs a function in two or more braking systems. A failure of any single component, or a failure of any common component; shall not reduce the effectiveness of the machine's stopping capability below the secondary stopping performance as defined in Table 1A, 1B or clause 3.2.7.26 as applicable.

3.2.7.9 Braking Systems Performance

3.2.7.10 Service Braking System The vehicle shall have a service braking system. The service braking system shall be tested in accordance with Section 4.3 and shall stop the vehicle within the distances specified in Table 1A, 1B, or clause 3.2.7.26, as applicable. This criteria shall apply to both directions of travel.

3.2.7.11 The Service Braking System shall have the capability to temporarily hold the vehicle stationary, while the operator is applying the brake, on the maximum grade for which the machine is rated by the manufacturer.

3.2.7.12 Service Braking System Application. The maximum allowable force to actuate the service braking system shall be 667 n (150 lbf) for a foot operated system or 222 n (50 lbf) for a hand operated system.

3.2.7.13 Service Braking System Warning Device. A service braking system using stored energy shall be equipped with a device which is activated by partial depletion of energy, to warn the operator before the braking system is automatically applied.

3.2.7.14 Vehicles fitted with multiple hydraulic braking circuits shall have a device to warn the operator of failure in any one hydraulic circuit.

3.2.7.15 The warning devices required by clauses 3.2.7.13 & 14 shall be readily visible and/or audible to the operator and provide continuous warning.

3.2.7.16 Secondary Braking System The vehicle shall have a secondary braking system.

3.2.7.17 The secondary braking system shall be tested in accordance with clause 4.3.6 and shall stop the vehicle within the distances specified in Table 1 below. This criteria shall apply to both directions of travel.

3.2.7.18 Secondary Braking System Application. The control for the secondary braking system shall be positioned so that actuation can be made by the operator while at the operator's station. The maximum allowable force to actuate the secondary braking system shall be 667 n (150 lbf) for a foot operated system or 222 n (50 lbf) for a hand operated system. Failure of the service brake system shall automatically apply the secondary braking system.

3.2.7.19 Parking Brake System. The vehicle shall have a parking brake system.

3.2.7.20 Parking Brake System Performance. The parking brake system shall be tested in accordance with clause 4.3.7 and shall have the capability to hold the vehicle stationary on the maximum grade specified in clause 3.2.7.2, multiplied by a factor of 1.3. The criteria shall apply in both directions of travel.

3.2.7.21 The parking brake system, while applied, shall perform in compliance with clause 3.2.7.20 regardless of any contraction of the system parts, exhaustion of the source of energy or leakage of any kind.

3.2.7.22 Parking Brake System Application. The parking brake on vehicles using a stored energy braking system shall be applied automatically whenever the vehicle has been stopped and de-energized or shut down by any means. The parking brake system shall be capable of being

manually applied without de-energizing or shutting down the vehicle.

3.2.7.23 The parking brake system, once applied, shall not be capable of being released by operation of controls governing any other function of the vehicle.

3.2.7.24 Parking Brake System application shall be indicated by a warning signal which shall be obvious to the operator.

3.2.7.25 Brake Performance Requirements (see table 1A, and 1B)

3.2.7.26 Vehicles designed to be operated on grades exceeding 20% shall have an increased braking performance which is related to increase in grade. The level roadway deceleration performance of Table 1B, shall be increased by 1% g for each percentage of increase in grade in excess of 20% on which the vehicle is designed to be operated. Refer to the test requirements of clause 4.3.3. The maximum allowable stopping distance shall be calculated in accordance with the following formula:

$$S = \frac{u^2}{2a} + 0.5u$$

where S is maximum allowable stopping distance
u is initial speed
a is deceleration as described above

3.2.8 Safety Shutdown System - Diesel Engine

3.2.8.1 Each vehicle shall be equipped with a safety shutdown system which will shut down the engine in response to signals received from sensors located as described in clauses 3.2.8.2 to 3.2.8.6 below.

3.2.8.2 Within the engine and exhaust coolant system, at the point of the highest coolant temperature before it returns to the cooling radiator. The safe shutdown temperature shall be established by the engine manufacturer.

3.2.8.3 In the gas stream of the exhaust system to satisfy the requirements of clause 3.3.6.

3.2.8.4 In the exhaust gas conditioner to register water levels when necessary.

3.2.8.5 At the discharge port of an air compressor to register temperature. The shutdown temperature shall be not more than 150°C (302°F).

3.2.8.6 In the following locations to transmit shutdown signals generated by the maximum permissible temperature specified by the manufacturer, or the shutdown temperature, whichever is the lesser as follows:

	Maximum Shutdown Temperature
Fluid in Hydrostatic drive reservoir	100°C (212°F)
Fluid in Hydrokinetic (torque convertor) drive reservoir	150°C (302°F)
Air in Pneumatic System receiver	150°C (302°F)

3.2.8.7 The automatic safety shutdown (other than the normal fuel flow control) by which the engine is shutdown shall ensure that the engine is not damaged and that internal combustion ceases within 30 seconds of initiation. Shutdown shall be effective even if combustible gas is ingested by the engine. The shutdown system shall also be operable manually from the control station.

3.2.8.8 In the case of non-flame proof flywheel housings, the safety system shall not permit engagement of the starting mechanism, while the engine is running under its own power (see Clause 3.3.3.2 below).

3.2.8.9 The starting mechanism shall be interlocked with the safety shutdown systems in such a way that restart-up is not possible should any of the safety shutdown systems described above have been brought into operation so as to

shut down the engine, until the unsafe condition has been rectified. A control to permit inhibition of shutdown signals (a safety shutdown system override control) may be provided by the vehicle manufacturer to allow normal startup of the vehicle. Such controls shall be arranged so that they are ineffective while the vehicle is in motion or require the use of a special tool or key to permit operation of the vehicle while in motion. *

3.2.8.10 If the engine overspeeds more than 20% above its governed speed, engine shutdown shall be initiated.

3.2.9 Safety Shutdown System - Brakes

3.2.9.1 The primary or the secondary stopping system shall be automatically actuated if fluid pressure within a drive train component falls below the pressure necessary to sustain the designed transmission of torque in either the driving or retarding mode.

3.2.10 Signal or Warning Device

3.2.10.1 Vehicles shall be provided with a warning horn which shall perform so as to produce a sound level, when mounted on a vehicle, of 82-102 dB (A) at a distance of 15.25 m (50 ft) directly in front of the vehicle. The sound frequency produced shall be between 700 and 2800 Hz. The control for the warning horn shall be in the operator's control station and within convenient reach of the operator.

3.2.10.2 Vehicles over 2500 kg (5512 lbs) gross vehicle weight and intended to be driven in two directions, approximately equal distances in each direction, shall be fitted with one or more warning horns whose output performance is as specified in clause 3.2.10.1 except that the specified sound level shall be achieved in both directions of travel at the specified distance from the vehicle.

3.2.11 Back up Alarm

3.2.11.1 Back up alarms shall be fitted to vehicles:

a) When required by Provincial regulation or,

b) When the operator, positioned in the control station of the vehicle does not have good visibility to the ground close to the vehicle, in both directions of travel.

3.2.11.2 Back up alarms shall have a predominant sound frequency range of 700-2800 Hz. The cycles of sound level pulsations from the alarm shall be of the order of 1-2/S and the duration of the "on" and "off" intervals shall be approximately equal in length.

3.2.11.3 The sound level of the alarm shall be within 77 dB (A) to 112 dB (A) at a distance of 10 meter (33 feet).

3.2.11.4 Back up alarms shall be interlocked with the direction control mechanism so that the alarm operates whenever the direction in which the driver does not have good visibility. The alarm is not required to operate while the vehicle engine is at rest.

3.2.12 **Noise Control** (Requires additonal consideration)

3.3 Explosion-Proof (Flameproof) Requirements

3.3.1 Safe Gaps and Joints

Interfaces between adjacent parts of explosion-proof (flameproof) components are categorized as follows and shall conform to the corresponding standard shown:

Description	Standard
(i) Simple flanged interfaces	CSA C22.2 No. 30
(ii) Venting devices e.g., plate type flame arrestors	IEC Publication 79-1

3.3.1.1 A threaded fastener associated with the interfaces described in 3.3.1 shall conform to the appropriate standard listed in 3.3.2 above and shall, in addition, be so constructed that when installed as stated by the manufacturer and stressed to the level and in the sequence stated by the manufacturer, loosening of the fastener will not occur. These bolts or nuts securing joints which do not require frequent attention (such as those securing exhaust manifolds) are to be wire locked, cotter-pinned or bent tab washer locked to guarantee maintenance of the flameproof joint in service. Such joints include all intake and exhaust system joints except:

a) flame trap joints (for which lock washers are acceptable)
b) scrubber filler plug
c) others subject to the judgement of the Certifying Agency

3.3.1.2 Restricted Use Of Aluminum and Aluminum Alloys

3.3.1.3 The use of aluminum and aluminum alloys, excluding the use of aluminum as an alloying agent in the manufacture of steel and bronze, is restricted as follows. Aluminum or aluminum alloys shall not be used for decals or information plates nor in paint, nor in exposed non-rotating external parts, unless no other suitable substitute can be found, in which case the part shall meet two of the three following conditions:

a) The material is sprayed with a zinc coating 0.1 mm (0.004") to 0.15 mm (0.006") thick.
b) The part is located in a non impact area.
c) The part is protected by an impact deflection baffle or guard.

3.3.1.4 Alloy materials not meeting the required conditions in clause 3.3.1.3 may be used providing the following composition restrictions are satisfied:

a) Aluminum plus titanium plus magnesium in any combination shall not exceed 15% of the total metal by volume in the alloy.

b) Titanium plus magnesium shall not exceed 6% of the total metal by volume in the alloy.

3.3.2 Electrical Equipment

3.3.2.1 Electrical Components Electrical components shall be either enclosed in flameproof enclosures conforming with CSA Standard C22.2, No. 30 or No. 145 (as applicable) or shall be intrinsically safe in accordance with CSA Standard C22.2, No. 157.

3.3.2.2 Interconnecting Wiring Wiring between components shall be either run in fire-resistant hose conduit or shall be in fire-resistant shielded portable trailing cable complying with the trailing cable requirements of CSA Standard C22.5 "Use of Electricity in Mines". Hose conduit shall have a minimum wall thickness of 4.76 mm (3/16") and shall be capable of passing the test for fire resistance given in Clause 4.7.4.2 below. Wiring shall be routed in the manner most likely to protect it from contact with sharp objects and from accidental damage. Cable glands and terminations shall comply with the requirements for the enclosures which they enter (e.g., flameproof).

3.3.2.3 Protection and Control All ungrounded conductors shall be provided with suitable overcurrent devices for the purpose of automatically opening the electrical circuit in the event of dangerous overload or a short-circuit. Such control, where practicable, shall meet the requirements of CSA Standard C22.1 "Safety Standards for Electrical Installations". Where the source of electrical power is external to the machine, such protection may be provided external to the machine.

3.3.2.4 Batteries Intrinsically safe batteries installed on the vehicle shall comply with CSA Standard C22.2 No. 157. Non-intrinsically safe batteries shall be enclosed in a flameproof enclosure and shall be a type that does not produce explosive concentrations of combustible gases in normal operations within the confines of the flameproof enclosure.

3.3.3 Starting System

3.3.3.1 Steel starter pinions shall only be used if the engagement mechanism cannot apply more than 20 Kgm (150 ft lbf) of impact energy; beryllium copper pinions shall only be used if the engagement impact energy is limited to a maximum of 48 Kgm (350 ft. lbf). Alternatively any starter pinion material may be used but the flywheel housing, in which the starter pinion and ring gear are located, shall conform to the flameproof requirements in Clauses 3.3.1 above and 3.3.5.5 below.

3.3.3.2 If non-flameproof flywheel housings are used, the safety system shall not permit engagement of the starting mechanism while the engine is running under its own power; see clause 3.2.8.8.

3.3.4 Engine Intake System

3.3.4.1 The engine intake system shall:

a) convey combustion air to the engine.

b) prevent transmission of internal engine combustion to a surrounding explosive atmosphere in accordance with the flameproof requirements of clauses 3.3.4 and 4.6.1. Flameproof intake system components not complying with all the provisions of clauses 3.3.1 and 4.6.2 shall be subject to special requirements.

c) have a maximum surface temperature of 150°C (302°F) at full engine load.

d) filter the engine intake air in accordance with the engine manufacturer's recommendations.

e) be so designed that the minimum intake system air velocity in the flameproof parts of the engine intake system is such that flame stabilization of an ingested combustible gas-air mixture shall not occur.

3.3.5 Engine Requirements

3.3.5.1 The engine will be liquid cooled in accordance with the provisions of clause 3.3.5.2 below.

3.3.5.2 Normal diesel engine design, the design of fastenings associated with the joints in this clause, and normal manufacturing tolerances and wear limits provide acceptable flameproof barriers for the joint clearances between:

a) pistons and piston rings
b) pistons and cylinder walls
c) piston rings and cylinder walls
d) cylinder head to cylinder block
e) valve stem to valve guide
f) injector body to cylinder head

Any joints other than those listed above which directly or indirectly connect the combustion chamber to the surrounding atmosphere must be flameproof in accordance with clause 3.3.1 above.

3.3.5.3 The engine crankcase breather shall not contain incendive material and shall not be connected to the air intake system of the engine. The discharge from the breather shall be directed away from hot surfaces and in such a way as to ensure that the external surfaces of the engine and exhaust system do not become fouled with oil.

3.3.5.4 The oil filler and oil dipstick shall be secured in position by positive means which do not rely solely on friction and which prevent loss of oil from the interior of the engine.

3.3.5.5 The engine flywheel, clutch and starter ring gear housing must be flameproof as described above in clause 3.3.3.1 unless clutch and starter impact energies are below the maximum values stated therein.

3.3.6 Engine Exhaust System

3.3.6.1 The engine exhaust system shall:

a) convey the products of combustion away from the engine.

b) prevent transmission of internal engine combustion to a surrounding explosive atmosphere in accordance with the flameproof requirements of clause 3.3.1 and 4.6.1. Flameproof exhaust system components not complying with all the provisions of clause 4.6.1 shall be subject to special requirements. (see note below)

c) have a maximum surface temperature at full engine load of 150°C (302°F).

d) cool the exhaust gas before dilution with the mine atmosphere to a temperature of no more than 85°C for a minimum of 2 2/3 hours at full engine load automatically and without intervention by the operator or other personnel.

e) dilute the exhaust gas to fulfill the requirements of clause 3.5.5.

f) be resistant to corrosion, especially in areas where flameproof integrity may be affected, (such as gasketed joints).

Note: A flexible bellows assembly may not meet all the requirements of clause 3.3.1 and 4.6.2 but will be permitted provided that its failure initiates shutdown of the engine automatically by being constructed so that it is double-walled with the annulus liquid cooled or that it is double walled with annulus pressurized by air or inert gas where loss of pressure shall initiate an automatic engine shutdown.

3.3.7 Brake and Clutch

3.3.7.1 Dry Type Brakes and Clutches

3.3.7.1.1 To maintain the component parts of brake and clutch systems at acceptably low temperatures, the following maximum power dissipation to brake and clutch surface area ratio criteria shall apply:

a) "enclosed" shoe/drum/clutch plate system where "enclosed" infers inhibited cooling

0.20 kw/cm^2 (1.7 BHP/in^2)

b) "open" caliper/disc/clutch plate systems where "open" infers rigid cooling

0.40 kw/cm^2 (3.5 BHP/in^2)

Brake and clutch linings must be of a type to minimize incendive sparking by frictional contact and the brake or clutch system design must ensure that the brake or clutch linings are prevented from unintentional contact with rotating parts when not in braking or clutching position.

3.3.7.2 Wet Type Brakes The surface temperature of the housing of totally enclosed wet type brakes shall not exceed 150°C (302°F).

3.3.8 Anti-Static Materials Anti-static materials shall be used whenever the use of a static-producing material would generate hazardous levels of electrical energy as defined in Testing clause 4.6.3.1. Anti-static materials shall be used for but not limited to conveyor belts, V-belts, and plastic cooling fans. All materials shall be tested in accordance with the requirements of clause 4.6.3.

3.3.9 Air Compressors

3.3.9.1 Air compressors shall be liquid cooled.

3.3.9.2 Air compressors shall be equipped with a sensor in the discharge port which shall initiate engine shutdown at not more than 150°C (302°F).

3.3.9.3 Air compressors with a capacity exceeding 0.556 m^3/min (20 cfm) shall be designed for use with fire resistant lubricants.

3.4 Fire Prevention Requirements

3.4.1 Surface Temperature Limitations The external surface temperature of all vehicle components shall not exceed 150°C (302°F) under any operating or test condition, measured in still air in an ambient temperature of at least 14°C (57.2°F). Exterior surfaces shall be designed to minimize accumulation of dust and combustible material and facilitate removal of same. The use of water sprays in lieu of water jacketed components is discouraged.

3.4.2 Fire Resistant Fluids The resistance to fire of the fluids used in all hydraulic systems shall be in accordance with CSA Standard M423.

3.4.3 Fire Resistant Materials Wherever fire resistant materials can be obtained and perform adequately they shall be employed in the manufacture of flameproof machines. Such materials shall be used for, but not limited to conveyor belts and V-belts. All such materials shall be tested in accordance with the requirements described in section 4.7.4.

3.4.4 Mechanical Protection Mechanical protection of fuel lines is specified above in clause 3.2.3.5. In general, design shall be such as to protect parts containing flammable fluids from damage by impact, including the engine pan.

3.4.5 Fire Suppression

3.4.5.1 Hand Held Fire Extinguishers One or more approved multi-purpose (class A, B, C) hand-held fire extinguisher(s) shall be fitted to each diesel vehicle. They shall be readily accessible from the operator's compartment and conform to the following minimum requirements:

Vehicle Power Rating		Fire Extinguisher Type A, B, C Normal Capacity	
kw	(BHP)	kg	lb
0-37	(0-50)	2.3	(5)
37-75	(50-100)	4.5	(10)
75-112	(100-150)	9	(20)
112 plus	(150 plus)	9*	(20)*

* Additional equipment required; refer to following clause 3.4.6.2.

3.4.5.2 Installed Multi-Nozzle Fire Suppression System Vehicles with a power rating greater than 112 Kw (150 bhp) shall be fitted with an installed multi-nozzle fire suppression system in addition to the hand-held extinguisher provision in clause 3.4.5.1. The installed multi-nozzle system when required shall deliver fire suppressant chemical or gas to each location on the machine where a hazard potentially exists or a minimum of 5 locations, with a minimum of 8 nozzles, including one for each side of the engine compartment. Dry type chemical systems shall have a balanced distribution and shall supply a nominal 2.3 Kg (5 lb) of dry chemical per hazardous area, with a minimum nominal capacity of 12 Kg (25 lb). Manual activation of the installed multi-nozzle fire suppression system shall be possible from each side of the machine and at the operator's station. Where the actuator at the operator's station is readily accessible from ground level it will be sufficient to install one other actuator on the opposite side of the machine, also accessible from ground level.

3.5 Exhaust Emissions Requirements

3.5.1 Fuel Rate Setting The liquid fuel supply to the new engine shall be adjusted, fixed and sealed so that the undiluted exhaust gas shall contain not more than 2500 ppm of carbon monoxide, not more than 1500 ppm of oxides of nitrogen (NO_x) and not more than 150 mg/m^3 of particulate within the full design range of engine output, when the intake air mixture to the engine is either 100% air, or 1.25% methane by volume in air. Reduction in the maximum allowable fuel injection rate for increases in altitude above 300 metres (approximately 1,000 feet) shall be made.

3.5.2 Fuel Alteration System Innovations which alter the fuel and which beneficially affect the emissions, provided that they are practicable and that emissions tests of Clause 3.5.3 below reflect their beneficial effects, shall be permitted.

3.5.3 Exhaust Treatment Devices Exhaust treatment may be accomplished by a number of devices; for example, filters and water scrubbers, applied singly or in combination. Where evidence can be furnished that treatment performance does not deteriorate with use and that suitable procedures can be instituted to maintain the device(s), their application will result in reduced ventilation assessments as defined in clause 3.5.4.2 below. The emissions reduction performance of all such devices will be assessed during dynamometer exhaust emissions tests as described in clause 4.9.1.

3.5.4 Emissions Toxicity Criterion

3.5.4.1 In order to establish the Exhaust Quality (EQI) Index for undiluted exhaust emitted from the diesel engine or the last treatment device, the concentration of the various pollutants contained in the exhaust shall be considered additive in accordance with the following expression:

$$EQI = \frac{(CO)}{50} + \frac{(NO)}{25} + \frac{(RCD)}{2} + 1.5\left[\frac{(SO_2)}{3} + \frac{(RCD)}{2}\right] + 1.2\left[\frac{(NO_2)}{2} + \frac{(RCD)}{2}\right]$$

where:
- EQI = Exhaust Quality Index
- (CO) = carbon monoxide concentration (ppm)
- (NO) = nitric oxide concentration (ppm)
- (RCD) = respirable combustible dust concentration (mg/m^3)
- (SO_2) = sulphur dioxide concentration (ppm)
- (NO_2) = nitrogen dioxide concentration (ppm)

3.5.4.2 Ventilation air requirement shall be based on a dilution ratio of (EQI/3) where 3 is the maximum value of the index for ambient mine air, i.e. Air Quality Index (AQI) in accordance with the calculation prescribed in clause 4.9.2 below.

3.5.4.3 In circumstances where unusually low amounts of diesel particulates are emitted from the machine, it may be that the concentration of one or more of the gaseous emissions will exceed the ACGIH-TLV. In such a case sufficient ventilating air shall be provided to ensure that the concentration of each toxic constituent, taken separately, does not exceed its TLV at its maximum rate of generation.

3.5.5 Exhaust Dilution System The dilution system shall dilute the initial concentration of toxic exhaust constituents (under engine operating conditions producing maximum output of these constituents) to an AQI of 6 at the operator's breathing zone when tested in still, uncontaminated air. No exhaust constituent designated as having a "C" (Ceiling) rating should exceed that rating at the operator's breathing zone.

4. Vehicle Performance Tests

4.1 Exhaust System Cooling Capacity Evaluation

Tests shall be undertaken to determine directly by dynamometer tests or indirectly by engineering calculations, the capacity of the exhaust system to continuously cool the exhaust gases to 90°C (194°F) for a period of 2 2/3 hours at maximum rated load and speed. See clause 3.3.6.1.(d).

4.2 Safety Shutdown System Operation Confirmation

The operation of all safety shutdown devices on a completed vehicle shall be checked against the code performance requirements during factory or field inspection.

4.3 Braking Systems Tests

4.3.1 Facilities Required- Service Braking System, Secondary System, and Parking System Test Course The test course shall consist of a clean, dry surface, not to exceed a 2% rolling resistance. The test surface shall not exceed a 1% grade in the direction of travel or more than a 3% grade at right angles to the direction of travel. The approach shall be of sufficient length, smoothness, and uniformity of grade to ensure stabilized travel speed of the machine.

4.3.2 Instrumentation Required

a). A means to measure the stopping distance within ± 5%.

b) A means to measure test speed within ± 5%.

c) A means for determining the vehicle mass (weight) within ± 5%.

d) A means for measuring the braking system energy source level ± 5%.

e) A means for measuring the force required by the operator to actuate the braking system within ± 5%.

4.3.3 Test Requirements The braking systems as installed on the test vehicle shall be adjusted to the vehicle manufacturer's specifications. The test mass of a load-carrying vehicle shall be the manufacturer's maximum recommended gross vehicle mass for such a vehicle. The test mass of a non-load carrying vehicle shall be the in-service weight of such a vehicle. The stopping distance shall be measured from the roadway location of a point on the machine at the time of initiation of the brake application device to the same point on the machine when it has stopped. The stopping test shall be conducted at the maximum rated speed of the test vehicle, using the lowest ratio drive which can be selected (top gear). Auxiliary retarders shall not be used during stopping test.

4.3.4 Service Braking System Recovery Test With the vehicle stationary, the service braking system's primary power source shall have the capability of delivering at least 70% of maximum brake pressure measured at the brakes when the brakes are fully applied twelve (12) times at the rate of four (4) applications per minute, with engine idling.

4.3.5 Test Procedure - Service Brake System Performance Prepare and drive the test vehicle over the test course defined in clause 4.3.1 and apply the service brakes. Record the maximum force to actuate the service braking system. This force shall be in accordance with Section 3.2.7.12. Record the stopping distance. The prescribed test procedures shall be repeated a minimum of ten times in succession, five in each operational direction without change or adjustment of the braking system and at intervals not to exceed five minutes between each brake test for brake cooling. The stopping capability of the service braking system shall be the average distance obtained in the tests for each direction and shall comply with the distances in Tables 1A, 1B, or clause 3.2.7.26, as applicable.

4.3.6 Test Procedure - Secondary Braking System Performance Prepare and drive the test vehicle over the test course defined in clause 4.3.1 and actuate the secondary braking system. Record the maximum force to actuate the secondary braking system. This force shall be in accordance with clause 3.2.7.18. Record the stopping distance. The prescribed test procedures shall be repeated a minimum of ten times in succession, five in each operational direction without change or adjustment of the braking system and at intervals not to exceed five minutes between each brake test for brake cooling. The stopping capability of the secondary braking system shall be the average distance obtained in the tests for each direction and shall comply with the distances in Table 1A, 1B or clause 3.2.7.26, as applicable.

4.3.7 Test Procedure - Parking System Holding Performance
The parking system shall be tested by stopping and then de-energizing or shutting down the vehicle. The holding performance test shall be conducted as prescribed in the following paragraphs with the transmission in neutral, if applicable, and with all parking system components at ambient temperatures. One of the following tests shall be performed on the test course as defined in clause 4.3.1. The parking system shall prevent vehicle movement, excluding drive train slack, in either direction, for one of the tests described below.

a) Apply a force to the vehicle along the longitudinal axis of the vehicle and parallel to the test surface on the horizontal centre line of the vehicle. The force applied shall be equal to the sine of the angle of the maximum grade on which the vehicle is rated by the manufacturer to operate, multiplied by the vehicle's test mass multiplied by a factor of 1.3.

Repeat the test in the opposite direction.

b) Stop the vehicle on a grade equal to 1.3 times or greater than the grade rating of the vehicle and then de-energize or shut down. Repeat the test in the opposite direction. The test surface condition shall be in accordance with clause 4.3.1.

4.4 Fuel Tank Leak Check Fuel tanks shall be tested by the manufacturer in accordance with clause 3.2.3.3.

4.5 Headlight Intensity Check The headlight intensity shall be assessed in accordance with the requirements of clause 3.2.1.

4.6 Explosion Pressure, Hydrostatic Proof, and Flame Propagation Tests - Engine Systems

4.6.1 Explosion Proof Enclosure Tests Refer to CSA Standard C22.2 No. 30 and IEC Publication 79-2 Modification 1, as applicable for flameproofness and overpressure tests for structural adequacy of explosion proof enclosures. Explosion tests will be required in accordance with the appropriate document. Flameproof electrical/mechanical equipment shall be subjected to the following pressure tests as applicable. Leak test: all intake and exhaust system castings and weldments shall be leak tested to a pressure of 3.5 atmospheres hydrostatically on a routine basis at the factory, in order to ensure leakproof fabrication. This factory test requirement shall be noted on all appropriate assembly drawings and listed on the Factory Inspection Form as a routine inspection requirement. In addition, the maximum explosion pressure test, the routine hydrostatic test, the hydrostatic type test, and the flameproof test, as applicable will be undertaken in accordance with CSA Standard C22.2 No. 30 and IEC Publication 79-1 Modification 1, whichever is appropriate.

4.6.2 Impact Tests on Coated Aluminum Alloy Parts External parts made from coated aluminum alloy materials shall be evaluated for frictional impact hazard on the basis of results obtained from drop tests and judgements made with respect to their intended application.

4.6.3 Anti-Static Materials Tests

4.6.3.1 Anti-Static Rubber V-belt Test The method of ISO standard 1813-1976 (E) entitled "Anti-Static Endless V-Belts (sections Y, Z, A, B, C, D, E) - Electrical Conductivity - Characteristic and Method of Test" shall be used to "ensure that the belt is sufficiently conductive to dissipate charges of electricity which may form in it in service". This standard pertains to new belts intended to be used in an explosive atmosphere or in situations where there is a fire risk. These tests shall be performed if no adequately documented tests in accordance

with the Standard have been previously performed, and show the material to be acceptable. The test values of resistance thus determined shall be less than the specified maxima as determined by the following relation:

$$R_{max} = 6 \times 10^5 \times \frac{L}{I} \text{ ohms}$$

where L is the distance between the inner edges of the two electrodes and where I is the sum of the heights of the two sidewalls of the belt.

4.6.3.2 Anti-Static Plastic Engine Cooling Fans CSA Standard C22.2 No. 145 clause 2.3.3 states - "External rotating parts of non-metallic material shall be investigated for the generation of electrostatic charges if the resistance between the extreme ends of the part exceeds 10 megohms." The tip-to-tip and tip-to-hub resistances of the fan shall be determined. If the resistance exceeds 10 megohms the fan will not be acceptable.

4.6.3.3 Conveyor belts will be tested to CSA Standard M422.

4.7 Fire Prevention Tests

4.7.1 Fire Resistant Fluid Tests

Refer to CSA Standard M423.

4.7.2 Surface Temperature Checks:

Tests shall be carried out at various engine load/speed combinations with up to 1.25% methane in air mixture in the intake to determine the maximum external surface temperatures of the various vehicle components. The testing sequence shall also ensure that the vehicle safety devices prevent excessive surface temperatures in the event of:

a) Shortage of water in the cooling circuits.

b) Pneumatic or hydraulic system malfunctions, including hydraulic relief valves.

c) Heat build-up in components upon application such as in service, emergency and parking brake systems, in torque

converters particularly in a stalled condition, and in retarders.

d) Any other malfunctions which could produce elevated external surface temperatures on one or more of the vehicle components.

The temperature test may be made at any room temperature between 10°C and 40°C and the variation below 40°C shall be added to the observed temperatures before comparing with the values in clause 3.4.1.

4.7.3 Extinguisher System Checks Manufacturer's documentation for the design of multi-nozzle fire suppression system or a physical demonstration of the effectiveness of coverage will be accepted. Certification by Underwriters Laboratories or Factory Mutual will be accepted as part of the documentation.

4.7.4 Fire Resistant Materials Tests

4.7.4.1 Conveyor Belt Tests The conveyor belt tests and specifications are described in CSA Standard M422 entitled "Fire- Resistant Conveyor Belting".

4.7.4.2 Hose Tests The hose tests and specifications are similar to the tests described in CANMET, Division Report ERP/MRL 80-21(TR), clause 4.1 to 4.5, except for test purposes only 4 specimens each 6 inches long by ½ wide thickness of the hose are required.

4.7.4.3 Other Tests Other fire-resistant materials, such as V-belts, will be tested in a manner similar to the tests described above.

4.8 Electrical Systems Tests

4.8.1 Explosion-Proof Enclosures All tests of flameproof electrical enclosures shall conform to the provisions of Section 6 - "tests" of CSA Standard C22.2 No. 30 - 1970, entitled "Explosion-Proof Enclosures for use in Class I Hazardous Locations". This document describes:

a) the maximum explosion pressure test
b) overpressure tests
c) temperature tests
d) impact tests (including glass lenses) and,
e) materials flammability tests

4.8.2 Intrinsically Safe Systems All tests of intrinsically safe electrical systems shall conform to the provisions of Section 6 - "Tests" of CSA Standrd C22.2 No. 157 -M1979 "Intrinsically Safe and Non-Incendive Equipment for Use in Hazardous Locations."

4.8.3 Lighting System Lens Strength Test See clause 4.8.1 item d. above.

4.8.4 Electric Motors and Generators Electric motors and generators intended for hazardous locations applications will be tested to CSA Standard C22.2 No. I45.

4.9 Emissions Systems Tests

4.9.1 Dynamometer Emissions Tests Dynamometer tests on all systems which affect the levels of toxic emissions shall be performed in an approved laboratory or test facility. Such tests shall include but not necessarily be limited to:

a) confirmation of the maximum fuel rate setting
b) fuel alteration system performance evaluation if applicable
c) determination of untreated engine emissions
d) exhaust treatment device(s) performance evaluation if applicable
e) exhaust dilution system performance evaluation

Variations due to the addition of methane (CH_4) in the intake air will be determined for items (b) (c) and (d) above. The engine submitted for test will be pre-run to the extent required to allow it to be operated immediately at full load and speed in an approved laboratory or test facility. Couplings or adapters for attachment of the engine to the testing laboratory dynamometer will be

furnished by the Applicant. Clutches, transmissions or torque converters, are not generally required in the coupling train. The fuel employed for engine dynamometer Emission Tests shall conform to the appropriate CGSB Standard.

4.9.2 Assessed Ventilation Recommendations The results of tests at the engine operating conditions which produce the greatest toxicity hazard, and as specified in clause 4.9.1 shall be employed in the following equation to assess the ventilation recommendation for the exhaust leaving the last exhaust treatment device prior to exhaust dilution and emission into the environment:

$$Q_{dva} = \frac{M_{dxg} \times \frac{EQI}{3} + \frac{9H_2\%}{100} - 1 \; M_f}{60\ p} \quad m^3/min.$$

Where:

Q_{dva} is the flow rate of dry ventilating air for the diesel machine in cubic metres per minute

AQI is the Air Quality Index defined by clause 3.5.4

M_{dxg} is the dry exhaust gas rate produced by combustion of the fuel in kg/hr.

M_f is the fuel consumption rate at the rated horsepower in kg/hr.

p is the dry ventilating air density in kg/m^3

H_2 is the percent by weight of hydrogen in the fuel

The above recommended ventilation rate pertains to the worst engine operating conditions from an emissions toxicity point of view. Local conditions of altitude, methane concentration, vehicle loading cycle, machine density, mine layout, etc., will normally reduce this ventilation recommendation to the required level.

TABLE 1A*

Vehicles Having a Maximum Speed of 9.66 km/h (6 mph) or Less		
	Ratio of Brake Force to Gross Vehicle Mass	
Vehicle Speed	**Service Brakes**	**Secondary Brakes**
0 - 9.66 km/h (0-6 mph)	.32	.24

* The brake system application time between the start of brake system application and the commencement of measurable vehicle deceleration shall not exceed 0.5 s.

TABLE 1B

Vehicles Designed To Be Operated on Grades up to & Including 20%					
Vehicle Speed		**Maximum Stopping Distance (Level Ground)**			
		Service Brakes		**Secondary Brakes**	
km/h	**mph**	**m**	**ft.**	**m**	**ft.**
9.66-11.27	6-7	3.14	10.3	3.66	12.0
12.87	8	3.84	12.6	4.51	14.8
14.48	9	4.60	15.1	5.46	17.9
16.09	10	5.43	17.8	6.49	21.3
17.70	11	6.31	20.7	7.59	24.9
19.31	12	7.25	23.8	8.79	28.8
20.92	13	8.32	27.3	10.12	33.2
22.53	14	9.39	30.8	11.46	37.6
24.14	15	10.52	34.5	12.89	42.3
25.75	16	11.73	38.5	14.45	47.4
27.36	17	13.02	42.7	16.09	52.8
28.97	18	14.33	47.0	17.77	58.3
30.58	19	15.76	51.7	19.60	64.3
32.19	20	17.22	56.5	21.46	70.4

Note 1: The maximum stopping distances are based on an average level roadway deceleration of 0.32 g for service brakes and 0.24 g for secondary brakes.

Note 2: The maximum stopping distances include the distances travelled during brake system application time, of 0.5 seconds.